

Affidavits, Publications and Reports

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Part I of 2

1. R. Mills, W. Good, A. Voigt, Jinquan Dong, Minimum Heat of Formation of Potassium Iodo Hydride, Int. J. Hydrogen Energy, submitted.

It was previously reported [R. Mills, B. Dhandapani, N. Greenig, J. He, "Synthesis and Characterization of Potassium Iodo Hydride", Int. J. of Hydrogen Energy, Vol. 25, Issue 12, December, (2000), pp. 1185-1203.] that a novel inorganic hydride compound *KHI* which comprised a high binding energy hydride ion was synthesized by reaction of atomic hydrogen with potassium metal and potassium iodide. Potassium iodo hydride was identified by time of flight secondary ion mass spectroscopy, X-ray photoelectron spectroscopy, 1H and ^{39}K nuclear magnetic resonance spectroscopy, Fourier transform infrared spectroscopy, electrospray ionization time of flight mass spectroscopy, liquid chromatography/mass spectroscopy, thermal decomposition with analysis by gas chromatography, and mass spectroscopy, and elemental analysis. We report measurements of heats of formation of *KHI* by differential scanning calorimetry (DSC) on a very reliable commercial instrument, a Setaram HT 1000 DSC. With reactant *KI* present, potassium metal catalyst and atomic hydrogen were produced by decomposition of *KH* at an extremely slow rate under a helium atmosphere to increase the amount of atomic hydrogen by slowing the rate of molecular hydrogen formation. Since not all of the starting materials reacted, the observed minimum heats of formation were over -2000 kJ/mole H_2 , compared to the enthalpy of combustion of hydrogen of $-241.8\text{ kJ/mole H}_2$.

2. R. Mills, "Spectroscopic Identification of a Novel Catalytic Reaction of Atomic Hydrogen and the Hydride Ion Product", Int. J. Hydrogen Energy, submitted.

From a solution of a Schrödinger-type wave equation with a nonradiative boundary condition based on Maxwell's equations, Mills predicts that atomic hydrogen may undergo a catalytic reaction with certain atomized elements such as cesium and strontium atoms or certain gaseous ions such as Ar^+ which singly or multiply ionize at integer multiples of the potential energy of atomic hydrogen, 27.2 eV . The reaction involves a nonradiative energy transfer to form a hydrogen atom that is lower in energy than unreacted atomic hydrogen with the release of energy. Intense extreme

ultraviolet (EUV) emission was observed from incandescently heated atomic hydrogen and the atomized catalysts that generated the plasma at low temperatures (e.g. $\approx 10^3 K$). No emission was observed with cesium, strontium, argon, hydrogen, or an argon-hydrogen mixture (97/3%) alone or when sodium, magnesium, or barium replaced strontium or cesium with hydrogen or with an argon-hydrogen mixture. The emission intensity of the plasma generated by the cesium or strontium catalyst increased significantly with the introduction of argon gas only when Ar^+ emission was observed. Ar^+ which served as a second catalyst was generated by the formation of a plasma with cesium or strontium catalyst. Emission was observed from a continuum state of Cs^{2+} and Ar^{2+} at $53.3 nm$ and $45.6 nm$, respectively. The single emission feature with the absence of the other corresponding Rydberg series of lines from these species confirmed the resonant nonradiative energy transfer of $27.2 eV$ from atomic hydrogen to atomic cesium or Ar^+ . The catalysis product, a lower-energy hydrogen atom, was predicted to be a highly reactive intermediate which further reacts to form a novel hydride ion. The predicted hydride ion of hydrogen catalysis by either cesium atom or Ar^+ catalyst is the hydride ion $H^-(1/2)$. This ion was observed spectroscopically at $407 nm$ corresponding to its predicted binding energy of $3.05 eV$.

3. R. Mills, N. Greenig, S. Hicks, "Optically Measured Power Balances of Anomalous Discharges of Mixtures of Argon, Hydrogen, and Potassium, Rubidium, Cesium, or Strontium Vapor", Int. J. Hydrogen Energy, submitted.

The power balances of gas cells having atomized hydrogen from pure hydrogen alone, an argon-hydrogen mixture alone, or pure hydrogen or an argon-hydrogen mixture with vaporized potassium, rubidium, cesium, strontium, sodium, or magnesium were measured by integrating the total light output corrected for spectrometer system response and energy over the visible range. The light emitted for power supplied to the glow discharge increased by over two orders of magnitude depending on the presence of less than 1% partial pressure of certain of the alkali or alkaline earth metals in hydrogen gas or argon-hydrogen gas mixtures. Whereas, other chemically similar metals had no effect on the plasma. The metal vapor enhancement of the emission was dramatically greater with an argon-hydrogen mixture versus pure hydrogen, and a 97 % argon and 3 % hydrogen mixture had greater emission than either gas alone. Only those atoms or ions which ionize at integer multiples of the potential energy of atomic hydrogen, potassium, cesium, Rb^+ , strontium, and Ar^+ caused an increase in emission; whereas, no anomalous behavior was observed in the case of $Mg(m)$ and $Na(m)$ which do not provide a reaction with a net

enthalpy of a multiple of the potential energy of atomic hydrogen. The light intensity versus power input of a mixture of these metals with hydrogen, argon, or argon-hydrogen gas was the same as that of the corresponding gas alone. At an input power to the glow discharge of 10 watts, the optically measured light output power of a mixture of strontium, cesium, potassium, and rubidium with 97 % argon and 3 % hydrogen was $750, 70, 25, 15$, and $10 \mu\text{W}/\text{cm}^2$, respectively. Whereas, the optically measured light output power of sodium or magnesium with 97 % argon and 3 % hydrogen was about $5 \mu\text{W}/\text{cm}^2$, and the result for hydrogen or argon gas alone was $1.5 \mu\text{W}/\text{cm}^2$. A temperature dependence of some of the anomalous plasmas was determined corresponding to the partial pressure dependence of the metal. These studies provide useful parameters for the optimization of the catalytic reaction of atomic hydrogen.

4. R. Mills, "The Grand Unified Theory of Classical Quantum Mechanics", Global Foundation, Inc. Orbis Scientiae entitled The Role of Attractive and Repulsive Gravitational Forces in Cosmic Acceleration of Particles The Origin of the Cosmic Gamma Ray Bursts, (29th Conference on High Energy Physics and Cosmology Since 1964) Dr. Behram N. Kursunoglu, Chairman, December 14-17, 2000, Lago Mar Resort, Fort Lauderdale, FL, in press.

A theory of classical quantum mechanics (CQM), derived from first principles [1], successfully applies physical laws on all scales. The classical wave equation is solved with the constraint that a bound electron cannot radiate energy. The mathematical formulation for zero radiation based on Maxwell's equation's follows from a derivation by Haus [2]. The function that describes the motion of the electron must not possess spacetime Fourier components that are synchronous with waves traveling at the speed of light. CQM gives closed form solutions for the atom including the stability of the $n=1$ state and the instability of the excited states, the equation of the photon and electron in excited states, the equation of the free electron, and photon which predict the wave particle duality behavior of particles and light. The current and charge density functions of the electron may be directly physically interpreted. For example, spin angular momentum results from the motion of negatively charged mass moving systematically, and the equation for angular momentum, $\mathbf{r} \times \mathbf{p}$, can be applied directly to the wave function (a current density function) that describes the electron. The magnetic moment of a Bohr magneton, Stern Gerlach experiment, g factor, Lamb shift, resonant line width and shape, selection rules, correspondence principle, wave particle duality, excited states, reduced mass, rotational energies, and momenta, orbital and spin splitting, spin-orbital coupling, Knight shift, and spin-nuclear coupling

are derived in closed form equations based on Maxwell's equations. The calculations agree with experimental observations.

For or any kind of wave advancing with limiting velocity and capable of transmitting signals, the equation of front propagation is the same as the equation for the front of a light wave. By applying this condition to electromagnetic and gravitational fields at particle production, the Schwarzschild metric (SM) is derived from the classical wave equation which modifies general relativity to include conservation of spacetime in addition to momentum and matter/energy. The result gives a natural relationship between Maxwell's equations, special relativity, and general relativity. It gives gravitation from the atom to the cosmos. The universe is time harmonically oscillatory in matter energy and spacetime expansion and contraction with a minimum radius that is the gravitational radius. In closed form equations with fundamental constants only, CQM gives the deflection of light by stars, the precession of the perihelion of Mercury, the particle masses, the Hubble constant, the age of the universe, the observed acceleration of the expansion, the power of the universe, the power spectrum of the universe, the microwave background temperature, the uniformity of the microwave background radiation, the microkelvin spatial variation of the microwave background radiation, the observed violation of the GZK cutoff, the mass density, the large scale structure of the universe, and the identity of dark matter which matches the criteria for the structure of galaxies. In a special case wherein the gravitational potential energy density of a blackhole equals that of the Plank mass, matter converts to energy and spacetime expands with the release of a gamma ray burst. The singularity in the SM is eliminated.

**5. R. Mills, "The Grand Unified Theory of Classical Quantum Mechanics", II
Nuovo Cimento, submitted.**

A theory of classical quantum mechanics (CQM) is derived from first principles that successfully applies physical laws on all scales. Using Maxwell's equations, the classical wave equation is solved with the constraint that a bound electron cannot radiate energy. By further application of Maxwell's equations to electromagnetic and gravitational fields at particle production, the Schwarzschild metric (SM) is derived from the classical wave equation which modifies general relativity to include conservation of spacetime in addition to momentum and matter/energy. The result gives a natural relationship between Maxwell's equations, special relativity, and general relativity. It gives gravitation from the atom to the cosmos.

6. R. Mills and M. Nansteel, "Anomalous Argon-Hydrogen-Strontium Discharge", IEEE Transactions of Plasma Science, submitted.

We report the observation of intense extreme ultraviolet (EUV) emission from incandescently heated atomic hydrogen and atomized strontium that increased with argon. Typically the emission of extreme ultraviolet light from hydrogen gas is achieved via a discharge at high voltage, a high power inductively coupled plasma, or a plasma created and heated to extreme temperatures by RF coupling (e.g. $>10^6$ K) with confinement provided by a toroidal magnetic field. The observed plasma formed at low temperatures (e.g. $\approx 10^3$ K) from atomic hydrogen generated at a tungsten filament that heated a titanium dissociator and atomic strontium which was vaporized from the metal by heating. The emission intensity of the plasma generated by atomic strontium increased significantly with the introduction of argon gas only when Ar^+ emission was observed. No emission was observed with hydrogen when sodium, magnesium, or barium replaced strontium or with hydrogen, hydrogen-argon mixtures, or strontium alone. The power balance of a gas cell having vaporized strontium and atomized hydrogen from pure hydrogen or argon-hydrogen mixture (77/23%) was measured by integrating the total light output corrected for spectrometer system response and energy over the visible range. Hydrogen control cell experiments were identical except that sodium, magnesium, or barium replaced strontium. In the case of hydrogen-sodium, hydrogen-magnesium, and hydrogen-barium mixtures, 4000, 7000, and 6500 times the power of the hydrogen-strontium mixture was required, respectively, in order to achieve that same optically measured light output power. With the addition of argon to the hydrogen-strontium plasma, the power required to achieve that same optically measured light output power was reduced by a factor of about two. The power required to maintain a plasma of equivalent optical brightness with strontium atoms present was 8600 and 6300 times less than that required for argon-hydrogen and argon control, respectively. A plasma formed at a cell voltage of about 250 V for hydrogen alone and sodium-hydrogen mixtures, 140-150 V for hydrogen-magnesium and hydrogen-barium mixtures, 224 V for an argon-hydrogen mixture, and 190 V for argon alone; whereas, a plasma formed for hydrogen-strontium mixtures and argon-hydrogen-strontium mixtures at extremely low voltages of about 2 V and 6.6 V, respectively.

7. R. Mills, B. Dhandapani, M. Nansteel, J. He, A. Voigt, Identification of Compounds Containing Novel Hydride Ions by Nuclear Magnetic Resonance Spectroscopy, Int. J. Hydrogen Energy, submitted.

Novel inorganic alkali and alkaline earth hydrides of the formula MH^* , MH_2^* , and MH^*X wherein M is the metal, X , is a halide, and H^* comprises a novel high binding energy hydride ion were synthesized in a high temperature gas cell by reaction of atomic hydrogen with a catalyst and MH , MH_2 , or MX corresponding to an alkali metal or alkaline earth metal compound, respectively. Novel hydride ions of the corresponding novel hydride compounds were characterized by an extraordinary upfield shifted peak observed by 1H nuclear magnetic resonance spectroscopy.

8. R. Mills, "BlackLight Power Technology-A New Clean Energy Source with the Potential for Direct Conversion to Electricity", Global Foundation International Conference on "Global Warming and Energy Policy", Dr. Behram N. Kursunoglu, Chairman, Fort Lauderdale, FL, November 26-28, 2000, in press.

BlackLight Power, Inc. (the Company), a Delaware corporation based in its 53,000 sq. ft. headquarters in Cranbury, New Jersey, believes it has developed a new hydrogen chemical process that generates power, plasma (a hot ionized glowing gas), and a vast class of new compositions of matter. Specifically, the Company has designed and tested a new proprietary energy-producing chemical process. The Company has developed high-power density, high-temperature, hydrogen gas cells that produce intense light, power of orders of magnitude greater than that of the combustion of hydrogen at high temperatures, and power densities equal to those of many electric power plants. The Company is focusing on cells for generating light and plasma for lighting applications and direct conversion to electricity, respectively.

The cells generate energy through a chemical process (BlackLight Process) which the Company believes causes the electrons of hydrogen atoms to drop to lower orbits thus releasing energy in excess of the energy required to start the process. The lower-energy atomic hydrogen product of the BlackLight Process reacts with an electron to form a hydride ion which further reacts with elements other than hydrogen to form novel compounds called hydrino hydride compounds (HHCs) which are proprietary to the Company. The Company is developing the vast class of proprietary chemical compounds formed via the BlackLight Process. Its technology has far-reaching applications in many industries.

The power may be in the form of a plasma, a hot ionized glowing gas. The plasma may be converted directly to electricity with high efficiency using a known microwave device called a gyrotron, thus, avoiding a heat engine such as a turbine. The Company is working on direct plasma to electricity conversion. The device is

linearly scaleable from the size of hand held units to large units which could replace large turbines.

There are many advantages of the technology. The energy balance permits the use of electrolysis of water to split water into its elemental constituents of hydrogen and oxygen as the source of hydrogen fuel using a small fraction of the output electricity. Additionally, pollution produced by fossil and nuclear fuels should be eliminated since no green house gases, air pollutants, or hazardous wastes are produced. As no fossil fuels are required, the projected commercial operating costs are much less than that of any known competing energy source.

The Company's process may start with water as the hydrogen source and convert it to HHCs; whereas, fuel cells typically require a hydrocarbon fuel and an expensive reformer to convert hydrocarbons to hydrogen and carbon dioxide. The Company's plasma to electric conversion technology with no reformer, no fuel cost, creation of a valuable chemical by-product rather than pollutants such as carbon dioxide, and significantly lower capital costs and operating and maintenance (O&M) costs are anticipated to result in household units that are competitive with central power and significantly superior to competing microdistributed power technologies such as fuel cells.

9. R. Mills, The Nature of Free Electrons in Superfluid Helium--a Test of Quantum Mechanics and a Basis to Review its Foundations and Make a Comparison to Classical Theory, Int. J. Hydrogen Energy, submitted.

The Schrödinger equation was originally postulated in 1926 as having a solution of the one electron atom. It gives the principal energy levels of the hydrogen atom as eigenvalues of eigenfunction solutions of the Laguerre differential equation. But, as the principal quantum number $n > 1$, the eigenfunctions become nonsensical. Despite its wide acceptance, on deeper inspection, the Schrödinger solution is plagued with many failings as well as difficulties in terms of a physical interpretation that have caused it to remain controversial since its inception. Only the one electron atom may be solved without approximations, but it fails to predict electron spin and leads to models with nonsensical consequences such as negative energy states of the vacuum, infinities, and negative kinetic energy. In addition to many predictions which simply do not agree with observations, the Schrödinger equation predicts noncausality, nonlocality, spook actions at a distance or quantum telepathy, perpetual motion, and many internal inconsistencies where contradicting statements have to be taken true simultaneously. Recently, the behavior of free electrons in superfluid

helium has again forced the issue of the meaning of the wavefunction. Electrons form bubbles in superfluid helium which reveal that the electron is real and that a physical interpretation of the wavefunction is necessary. Furthermore, when irradiated with light of energy of about a 0.5 to several electron volts [1], the electrons carry current at different rates as if they exist with different sizes. It has been proposed that the behavior of free electrons in superfluid helium can be explained in terms of the electron breaking into pieces at superfluid helium temperatures [1]. Yet, the electron has proven to be indivisible even under particle accelerator collisions at 90 GeV (LEPII). The nature of the wavefunction must now be addressed. It is time for the physical rather than the mathematical nature of the wavefunction to be determined. A theory of classical quantum mechanics (CQM) was derived from first principles by Mills [2] that successfully applies physical laws on all scales. Using the classical wave equation with the constraint of nonradiation based on Maxwell's equations, CQM gives closed form physical solutions for the electron in atoms, the free electron, and the free electron in superfluid helium. The prediction of fractional principal quantum energy states of the electron in liquid helium match the photoconductivity and mobility observations without requiring that the electron is divisible.

10. R. Mills, M. Nansteel, and Y. Lu, "Anomalous Hydrogen-Strontium Discharge", European Journal of Physics D, submitted.

We report the observation of intense extreme ultraviolet (EUV) emission from incandescently heated atomic hydrogen and atomized strontium. Typically the emission of extreme ultraviolet light from hydrogen gas is achieved via a discharge at high voltage, a high power inductively coupled plasma, or a plasma created and heated to extreme temperatures by RF coupling (e.g. $>10^6 K$) with confinement provided by a toroidal magnetic field. The observed plasma formed at low temperatures (e.g. $\approx 10^3 K$) from atomic hydrogen generated at a tungsten filament that heated a titanium dissociator and atomic strontium which was vaporized from the metal by heating. No emission was observed when sodium, magnesium, or barium replaced strontium or with hydrogen or strontium alone. The power balance of a gas cell having atomized hydrogen and strontium was measured by integrating the total light output corrected for spectrometer system response and energy over the visible range. Control cell experiments were identical except that sodium, magnesium, or barium replaced strontium. In the case of hydrogen-sodium, hydrogen-magnesium, and hydrogen-barium mixtures, 4000, 7000, and 6500 times the power of the hydrogen-strontium mixture was required, respectively, in order to achieve that same

optically measured light output power. A plasma formed at a cell voltage of about 250 V for hydrogen alone and sodium-hydrogen mixtures, and 140-150 V for hydrogen-magnesium and hydrogen-barium mixtures; whereas, a plasma formed for hydrogen-strontium mixtures at an extremely low voltage of about 2 V.

11. R. Mills, J. Dong, Y. Lu, "Observation of Extreme Ultraviolet Hydrogen Emission from Incandescently Heated Hydrogen Gas with Certain Catalysts", *Int. J. Hydrogen Energy*, Vol. 25, (2000), pp. 919-943.

Typically the emission of extreme ultraviolet light from hydrogen gas is achieved via a discharge at high voltage, a high power inductively coupled plasma, or a plasma created and heated to extreme temperatures by RF coupling (e.g. $>10^6 K$) with confinement provided by a toroidal magnetic field. We report the observation of intense EUV emission at low temperatures (e.g. $<10^3 K$) from atomic hydrogen and certain atomized pure elements or certain gaseous ions which ionize at integer multiples of the potential energy of atomic hydrogen.

12. R. Mills, "Observation of Extreme Ultraviolet Emission from Hydrogen-KI Plasmas Produced by a Hollow Cathode Discharge", *Int. J. Hydrogen Energy*, in press.

A high voltage discharge of hydrogen with and without the presence of a source of potassium, potassium iodide, in the discharge was performed at INP Greifswald, Germany with a hollow cathode. It has been reported that intense extreme ultraviolet (EUV) emission was observed at low temperatures (e.g. $<10^3 K$) from atomic hydrogen and certain atomized elements or certain gaseous ions which ionize at integer multiples of the potential energy of atomic hydrogen, $27.2 eV$ [1, 3-5]. Two potassium ions or a potassium atom may each provide an electron ionization or transfer reaction that has a net enthalpy equal to an integer multiple of $27.2 eV$. The spectral lines of atomic hydrogen were intense enough to be recorded on photographic films only when KI was present. EUV lines not assignable to potassium, iodine, or hydrogen were observed at 73.0, 132.6, 513.6, 677.8, 885.9, and 1032.9 Å. The lines are assigned to transitions of atomic hydrogen to lower energy levels corresponding to lower energy hydrogen atoms called hydrino atoms and the emission from the excitation of the corresponding hydride ions formed from the hydrino atoms.

13. R. Mills, "Temporal Behavior of Light-Emission in the Visible Spectral Range from a Ti-K₂CO₃-H-Cell", *Int. J. Hydrogen Energy*, in press.

INP Greifswald, Germany reports the generation of a hydrogen plasma and extreme ultraviolet emission as recorded via the hydrogen Balmer emission in the visible range. Typically a hydrogen plasma is generated and the emission of extreme ultraviolet light from hydrogen gas is achieved via a discharge at high voltage, a high power inductively coupled plasma, or a plasma created and heated to extreme temperatures by RF coupling (e.g. $>10^6 K$) with confinement provided by a toroidal magnetic field. The observed plasma formed at low temperatures (e.g. $\approx 10^3 K$) from atomic hydrogen generated at a tungsten filament that heated a titanium dissociator coated with potassium carbonate. The temporal behavior of the plasma was recorded via hydrogen Balmer alpha line emission when all power into the cell was terminated. A two second decay of the plasma was observed after a fast decay of the electric field to zero. The persistence of emission following the removal of all of the power to the cell indicates that a novel chemical power source is present that forms an energetic plasma in hydrogen. No unusual behavior was observed with the control sodium carbonate.

14. R. Mills, T. Onuma, and Y. Lu, "Formation of a Hydrogen Plasma from an Incandescently Heated Hydrogen-Catalyst Gas Mixture with an Anomalous Afterglow Duration", *Int. J. Hydrogen Energy, in press.*

We report the generation of a plasma of hydrogen and certain alkali ions as recorded via EUV spectroscopy and the hydrogen Balmer and alkali line emissions in the visible range. Typically a hydrogen plasma is generated and the emission of extreme ultraviolet light from hydrogen gas is achieved via a discharge at high voltage, a high power inductively coupled plasma, or a plasma created and heated to extreme temperatures by RF coupling (e.g. $>10^6 K$) with confinement provided by a toroidal magnetic field. The observed plasma formed at low temperatures (e.g. $\approx 10^3 K$) from atomic hydrogen generated at a tungsten filament that heated a titanium dissociator and a catalyst comprising one of potassium, rubidium, cesium, and their carbonates and nitrates. These atoms and ions ionize to provide a catalyst with a net enthalpy of reaction of an integer multiple of the potential energy of atomic hydrogen ($m \cdot 27.2 \text{ eV}$ $m = \text{integer}$) to within 0.17 eV and comprise only a single ionization in the case of a potassium or rubidium ion. Whereas, the chemically similar atoms of sodium and sodium and lithium carbonates and nitrates which do not ionize with these constraints caused no emission. To test the electric dependence of the emission, the weak electric field of about 1 V/cm was set and measured to be zero in $< 0.5 \times 10^{-6} \text{ sec}$. An anomalous afterglow duration of about one to two seconds was recorded in the case

of potassium, rubidium, cesium, K_2CO_3 , $RbNO_3$, and $CsNO_3$. Hydrogen line or alkali line emission was occurring even though the voltage between the heater wires was set to and measured to be zero. These atoms and ions ionize to provide a catalyst with a net enthalpy of reaction of an integer multiple of the potential energy of atomic hydrogen to within less than the thermal energies at $\approx 10^3 K$ and comprise only a single ionization in the case of a potassium or rubidium ion. Since the thermal decay time of the filament for dissociation of molecular hydrogen to atomic hydrogen was similar to the anomalous plasma afterglow duration, the emission was determined to be due to a reaction of atomic hydrogen with a catalyst that did not require the presence of an electric field to be functional.

15. R. Mills, M. Nansteel, and Y. Lu, "Observation of Extreme Ultraviolet Hydrogen Emission from Incandescently Heated Hydrogen Gas with Strontium that Produced an Anomalous Optically Measured Power Balance", *Int. J. Hydrogen Energy, in press.*

We report the observation of intense extreme ultraviolet (EUV) emission from incandescently heated atomic hydrogen and atomized strontium. It has been reported that intense EUV emission was observed at low temperatures (e.g. $\approx 10^3 K$) from atomic hydrogen and certain atomized elements or certain gaseous ions which ionize at integer multiples of the potential energy of atomic hydrogen, $27.2 eV$ [1-4]. Strontium ionizes at integer multiples of the potential energy of atomic hydrogen. Typically the emission of extreme ultraviolet light from hydrogen gas is achieved via a discharge at high voltage, a high power inductively coupled plasma, or a plasma created and heated to extreme temperatures by RF coupling (e.g. $> 10^6 K$) with confinement provided by a toroidal magnetic field. The observed plasma formed at low temperatures (e.g. $\approx 10^3 K$) from atomic hydrogen generated at a tungsten filament that heated a titanium dissociator and atomic strontium which was vaporized from the metal by heating. No emission was observed when sodium, magnesium, or barium replaced strontium or when argon replaced hydrogen with strontium. The power balance of a gas cell having atomized hydrogen and strontium was measured by integrating the total light output corrected for spectrometer system response and energy over the visible range. A control cell was identical except that sodium replaced strontium. In this case, 4000 times the power of the strontium cell was required in order to achieve that same optically measured light output power. A plasma formed at a cell voltage of about 250 volts in the cell with hydrogen alone and in the cell with hydrogen and sodium; whereas, a plasma formed in the strontium cell at the extremely

low voltage of about 2 volts. The starting and maintenance discharge voltages were two orders of magnitude of that predicted by current theory or observed experimentally.

16. R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 2000 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com.

In 1926, Schrödinger postulated the equation, $H\Psi = E\Psi$, where Ψ is the wave function, H is the wave operator, and E is the energy of the wave. Mills has solved and published a solution of a Schrödinger type equation based on first principles. The central feature of this theory is that all particles (atomic-size and macroscopic particles) obey the same physical laws. Whereas Schrödinger postulated a boundary condition: $\Psi \rightarrow 0$ as $r \rightarrow \infty$, the boundary condition in Mills' theory was derived from Maxwell's equations [8]:

For non-radiative states, the current-density function must not possess space-time Fourier components that are synchronous with waves traveling at the speed of light.

Application of this boundary condition leads to a physical model of particles, atoms, molecules, and, in the final analysis, cosmology. The closed-form mathematical solutions contain fundamental constants only, and the calculated values for physical quantities agree with experimental observations.

An important feature of Mills theory is that it predicts that the Rydberg's equation given by

$$E_n = -\frac{e^2}{n^2 8\pi\epsilon_0 a_H} = -\frac{13.598 \text{ eV}}{n^2} \quad (1)$$

$$n = 1, 2, 3, \dots \quad (2)$$

where a_H is the Bohr radius for the hydrogen atom (52.947 pm), e is the magnitude of the charge of the electron, and ϵ_0 is the vacuum permittivity should be extended. Eq. (2), should be replaced by Eq. (3).

$$n = 1, 2, 3, \dots, \text{ and, } n = \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \dots \quad (3)$$

Some revisions to standard quantum theory are implied. Quantum mechanics becomes a real physical description as opposed to a purely mathematical model

where the old and the revised versions are interchangeable by a Fourier Transform operation.

The theories of Bohr, Schrödinger, and presently Mills all give the identical equation for the principal energy levels of the one electron atom (Eq. (1)). The Mills theory solves the two dimensional wave equation for the charge density function of the electron. And, the Fourier transform of the charge density function is a solution of the three dimensional wave equation in frequency (k, ω) space. Whereas, the Schrödinger equation solutions are three dimensional in spacetime. The energy is given by

$$\int_{-\infty}^{\infty} \psi H \psi d\nu = E \int_{-\infty}^{\infty} \psi^2 d\nu \quad (4)$$

$$\int_{-\infty}^{\infty} \psi^2 d\nu = 1 \quad (5)$$

Thus,

$$\int_{-\infty}^{\infty} \psi H \psi d\nu = E \quad (6)$$

In the case that the potential energy of the Hamiltonian, H , is a constant times the wavenumber, the Schrödinger equation is the well known Bessel equation. Then with one of the solutions for ψ , Eq. (6) is equivalent to an inverse Fourier transform. According to the duality and scale change properties of Fourier transforms, the energy equation of the present theory and that of quantum mechanics are identical, the energy of a radial Dirac delta function of radius equal to an integer multiple of the radius of the hydrogen atom (Eq. (1)). And, Bohr obtained the same energy formula by postulating nonradiative states with angular momentum $L_z = m\hbar$ and solving the energy equation classically.

Mills revisions transform Schrödinger's quantum theory into what may be termed a *classical quantum theory*. Physical descriptions flow readily from the theory. For example, in the old quantum theory the spin angular momentum of the electron is called the "intrinsic angular momentum". This term arises because it is difficult to provide a physical interpretation for the electron's spin angular momentum. Quantum Electrodynamics provides somewhat of a physical interpretation by proposing that the "vacuum" contains fluctuating electric and magnetic fields. In contrast, in Mills' theory, spin angular momentum results from the motion of negatively charged mass moving systematically, and the equation for angular momentum, $\mathbf{r} \times \mathbf{p}$, can be applied directly to the wave function (a current density function) that describes the electron. And, quantization is carried by the photon, rather than probability waves of the electron.

Physics, 54, (1986), pp. 1126-1129.

18. R. Mills, B. Dhandapani, N. Greenig, J. He, "Synthesis and Characterization of Potassium Iodo Hydride", Int. J. of Hydrogen Energy, Vol. 25, Issue 12, December, (2000), pp. 1185-1203.

A novel inorganic hydride compound KHI which comprises a high binding energy hydride ion was synthesized by reaction of atomic hydrogen with potassium metal and potassium iodide. Potassium iodo hydride was identified by time of flight secondary ion mass spectroscopy, X-ray photoelectron spectroscopy, 1H and ^{39}K nuclear magnetic resonance spectroscopy, Fourier transform infrared spectroscopy, electrospray ionization time of flight mass spectroscopy, liquid chromatography/mass spectroscopy, thermal decomposition with analysis by gas chromatography, and mass spectroscopy, and elemental analysis. Hydride ions with increased binding energies may form many novel compounds with broad applications.

19. R. Mills, "Novel Inorganic Hydride", Int. J. of Hydrogen Energy, Vol. 25, (2000), pp. 669-683.

A novel inorganic hydride compound $KH\text{KHCO}$, which is stable in water and comprises a high binding energy hydride ion was isolated following the electrolysis of a K_2CO_3 electrolyte. Inorganic hydride clusters $K[KH\text{KHCO}]_n$ were identified by Time of Flight Secondary Ion Mass Spectroscopy. Moreover, the existence of a novel hydride ion has been determined using X-ray photoelectron spectroscopy, and proton nuclear magnetic resonance spectroscopy. Hydride ions with increased binding energies may be the basis of a high voltage battery for electric vehicles.

20. R. Mills, B. Dhandapani, M. Nansteel, J. He, "Synthesis and Characterization of Novel Hydride Compounds", Int. J. of Hydrogen Energy, in press.

Novel inorganic alkali and alkaline earth hydrides of the formula MH_2 and MH_2X wherein M is the metal, X is a singly negatively charged anion, and H comprises a novel high binding energy hydride ion were synthesized in a high temperature gas cell by reaction of atomic hydrogen with a catalyst and MX or M_2X , corresponding to an alkali metal or alkaline earth metal, respectively. It has been reported that intense extreme ultraviolet (EUV) emission was observed at low temperatures (e.g. $\approx 10^3 K$) from atomic hydrogen and certain atomized elements or certain gaseous ions which ionize at integer multiples of the potential energy of atomic hydrogen, $27.2 eV$ [1-5]. These atomized elements or certain gaseous ions comprised

the catalyst to form MHX and $MHMX$. For example, atomic hydrogen was reacted with strontium vapor and $SrBr_2$ to form $SrHBr$. Novel hydride compounds such as $SrHBr$ were identified by time of flight secondary ion mass spectroscopy, X-ray photoelectron spectroscopy, proton nuclear magnetic resonance spectroscopy, and thermal decomposition with analysis by gas chromatography, and mass spectroscopy. Hydride ions with increased binding energies form novel compounds with potential broad applications such as a high voltage battery for consumer electronics and electric vehicles. In addition, these novel compositions of matter and associated technologies may have far-reaching applications in many industries including chemical, electronics, computer, military, energy, and aerospace in the form of products such as propellants, solid fuels, surface coatings, structural materials, and chemical processes.

21. R. Mills, "Highly Stable Novel Inorganic Hydrides", Journal of Materials Research, submitted.

Novel inorganic hydride compounds $KH\ KHCO$, and KH were isolated following the electrolysis of a K_2CO_3 electrolyte. The compounds which comprised high binding energy hydride ions were stable in water, and KH was stable at elevated temperature (600 °C). Inorganic hydride clusters $K[KH\ KHCO_3]^+$ were identified by positive Time of Flight Secondary Ion Mass Spectroscopy (ToF-SIMS) of $KH\ KHCO_3$. The negative ToF-SIMS was dominated by hydride ion. The positive and negative ToF-SIMS of KH showed essentially K^+ and H^- only, respectively. Moreover, the existence of novel hydride ions was determined using X-ray photoelectron spectroscopy, and proton nuclear magnetic resonance spectroscopy. Hydride ions with increased binding energies may be the basis of a high voltage battery for electric vehicles.

22. R. Mills, "Novel Hydrogen Compounds from a Potassium Carbonate Electrolytic Cell", Fusion Technology, Vol. 37, No. 2, March, (2000), pp. 157-182.

Novel compounds containing hydrogen in new hydride and polymeric states which demonstrate novel hydrogen chemistry have been isolated following the electrolysis of a K_2CO_3 electrolyte with the production of excess energy. Inorganic hydride clusters $K[KH\ KHCO_3]^+$ and hydrogen polymer ions such as OH_{12}^+ and H_{16}^- were identified by time of flight secondary ion mass spectroscopy. The presence of compounds containing new states of hydrogen were confirmed by X-ray photoelectron spectroscopy, X-ray diffraction, Fourier transform infrared spectroscopy, Raman spectroscopy, and proton nuclear magnetic resonance spectroscopy.

23. R. Mills, "The Hydrogen Atom Revisited", Int. J. of Hydrogen Energy, Vol. 25, Issue 12, December, (2000), pp. 1171-1183.

Several myths about quantum mechanics exist due to a loss of awareness of its details since its inception in the beginning of the last century or based on recent experimental evidence. It is taught in textbooks that atomic hydrogen cannot go below the ground state. Atomic hydrogen having an experimental ground state of 13.6 eV can only exist in a vacuum or in isolation, and atomic hydrogen cannot go below this ground state in isolation. However, there is no known composition of matter containing hydrogen in the ground state of 13.6 eV. It is a myth that hydrogen has a theoretical ground state based on first principles. Historically there were many directions in which to proceed to solve a wave equation for hydrogen. The Schrödinger equation gives the observed spontaneously radiative states and the nonradiative energy level of atomic hydrogen. On this basis alone, it is justified despite its inconsistency with physical laws as well as with many experiments. A solution compatible with first principles and having first principles as the basis of quantization was never found. Scattering results required the solution to be interpreted as probability waves that give rise to the uncertainty principle which in turn forms the basis of the wave particle duality. The correspondence principle predicts that quantum predictions must approach classical predictions on a large scale. However, recent data has shown that the Heisenberg uncertainty principle as the basis of the wave particle duality and the correspondence principle taught in textbooks are experimentally incorrect. Recently, a reconsideration of the postulates of quantum mechanics, has given rise to a closed form solution of a Schrödinger-like wave equation based on first principles. Hydrogen at predicted lower energy levels has been identified in the extreme ultraviolet emission spectrum from interstellar medium. In addition, new compositions of matter containing hydrogen at predicted lower energy levels have recently been observed in the laboratory, which energy levels are achieved using the novel catalysts.

24. Labov, S., Bowyer, S., "Spectral observations of the extreme ultraviolet background", The Astrophysical Journal, 371, (1991), pp. 810-819.

25. Mills, R., Good, W., "Fractional Quantum Energy Levels of Hydrogen", Fusion Technology, Vol. 28, No. 4, November, (1995), pp. 1697-1719.

Determination of excess heat release during the electrolysis of aqueous

potassium carbonate by the very accurate and reliable method of heat measurement, flow calorimetry; describes the experimental identification of hydrogen atoms in fractional quantum energy levels—hydrinos—by X-ray Photoelectron Spectroscopy (XPS); describes the experimental identification of hydrogen atoms in fractional quantum energy levels—hydrinos—by emissions of soft X-rays from dark matter; describes the experimental identification of hydrogen molecules in fractional quantum energy levels—dihydrino molecules by high resolution magnetic sector mass spectroscopy with ionization energy determination, and gives a summary.

In summary:

Excess power and heat were observed during the electrolysis of aqueous potassium carbonate. Flow calorimetry of pulsed current electrolysis of aqueous potassium carbonate at a nickel cathode was performed in a single-cell dewar. The average power out of 24.6 watts exceeded the average input power (voltage times current) of 4.73 watts by a factor greater than 5. The total input energy (integration of voltage times current) over the entire duration of the experiment was 5.72 MJ; whereas, the total output energy was 29.8 MJ. No excess heat was observed when the electrolyte was changed from potassium carbonate to sodium carbonate. The source of heat is assigned to the electrocatalytic, exothermic reaction whereby the electrons of hydrogen atoms are induced to undergo transitions to quantized energy levels below the conventional "ground state". These lower energy states correspond to fractional quantum numbers: $n = 1/2, 1/3, 1/4, \dots$. Transitions to these lower energy states are stimulated in the presence of pairs of potassium ions (K^+/K^+ electrocatalytic couple) which provide 27.2 eV energy sinks.

The identification of the $n = 1/2$ hydrogen atom, $H(n = 1/2)$ is reported. Samples of the nickel cathodes of aqueous potassium carbonate electrolytic cells and aqueous sodium carbonate electrolytic cells were analyzed by XPS (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University). A broad peak centered at 54.6 eV was present only in the cases of the potassium carbonate cells. The binding energy (in vacuum) of $H(n = 1/2)$ is 54.4 eV. Thus, the theoretical and measured binding energies for $H(n = 1/2)$ are in excellent agreement.

Further experimental identification of hydrinos—down to $H(n = 1/8)$ —can be found in the alternative explanation by Mills et al. for the soft X-ray emissions of the dark interstellar medium observed by Labov and Bowyer [15] of the Extreme UV Center of the University of California, Berkeley. The agreement between the experimental spectrum and the energy values predicted for the proposed transitions is

remarkable.

The reaction product of two $H(n=1/2)$ atoms, the dihydrino molecule, was identified by mass spectroscopy (Shrader Analytical & Consulting Laboratories). The mass spectrum of the cryofiltered gases evolved during the electrolysis of a light water K_2CO_3 electrolyte with a nickel cathode demonstrated that the dihydrino molecule, $H_2(n = 1/2)$, has a higher ionization energy, about 63 eV, than normal molecular hydrogen, $H_2(n = 1)$, 15.46 eV. The high resolution (0.001 AMU) magnetic sector mass spectroscopic analysis of the postcombustion gases indicated the presence of two peaks of nominal mass two-- one peak at 70 eV and one peak at 25 eV. The same analysis of molecular hydrogen indicates only one peak at 25 eV and one peak at 70 eV. In the case of the postcombustion sample at 70 eV, one peak was assigned as the hydrogen molecular ion peak, $H_2^+(n = 1)$, and one peak was assigned as the dihydrino molecular peak, $H_2^+(n = 1/2)$ which has a slightly larger magnetic moment.

26. Mills, R., Good, W., Shaubach, R., "Dihydrino Molecule Identification", *Fusion Technology*, Vol. 25, 103 (1994).

Calorimetry of pulsed current and continuous electrolysis of aqueous potassium carbonate (K^+/K^+ electrocatalytic couple) at a nickel cathode was performed by Thermacore, Inc. The excess power out of 41 watts exceeded the total input power given by the product of the electrolysis voltage and current by a factor greater than 8. Elemental analysis of the electrolyte and metallurgical analysis of the cathode showed no evidence of chemical reactions. The pH, specific gravity, concentration of K_2CO_3 , and the elemental analysis of the electrolyte sample taken after 42 days of continuous operation were unchanged from that of the values obtained for the electrolyte sample taken before operation. Elemental analysis and scanning electron microscopy of metallurgical samples of the nickel cathode taken before operation and at day 56 of continuous operation were identical indicating that the nickel cathode had not changed chemically or physically. Scintillation counter and photographic film measurements showed that no radiation above background was detected indicating that nuclear reactions did not occur.

The "ash" of the exothermic reaction is atoms having electrons of energy below the "ground state" which are predicted to form molecules. The predicted molecules were identified by lack of reactivity with oxygen, by separation from molecular deuterium by cryofiltration, and by mass spectroscopic analysis. The combustion of the gases evolved during the electrolysis of a light water K_2CO_3 electrolyte (K^+/K^+

electrocatalytic couple) with a nickel cathode was incomplete. The mass spectroscopic analysis (Dr. David Parees of Air Products & Chemicals, Inc.) of the m/e = 2 peak of the combusted gas demonstrated that the dihydrino molecule, $H_2(n = 1/2)$, has a higher ionization energy than H_2 .

Calorimetry of pulsed current and continuous electrolysis of aqueous potassium carbonate (K^+/K^+ electrocatalytic couple) at a nickel cathode was performed in single cell dewar calorimetry cells by HydroCatalysis Power Corporation. Excess power out exceeded input power by a factor greater than 16. No excess heat was observed when the electrolyte was changed from potassium carbonate to the control sodium carbonate. The faraday efficiency was measured volumetrically to be 100%.

27. R. Mills and S. Kneizys, *Fusion Technol.* Vol. 20, 65 (1991).

Calorimetry of pulsed current and continuous electrolysis of aqueous potassium carbonate (K^+/K^+ electrocatalytic couple) at a nickel cathode was performed in single cell dewar calorimetry cells by Mills of Franklin and Marshall College and Kneizys of Ursinus College. Excess power out exceeded the input power by a factor greater than 37. No excess heat was observed when the electrolyte was changed from potassium carbonate to the control sodium carbonate.

28. V. Noninski, *Fusion Technol.*, Vol. 21, 163 (1992).

Dr. Noninski of the Laboratory for Electrochemistry of Renewed Electrode-Solution Interface (LEPGER) successfully reproduced the results of Mills and Kneizys [17] as a visiting professor at Franklin and Marshall College. A significant increase in temperature with every watt input, compared with the calibration experiment ($\approx 50^\circ C/W$ versus $\approx 30^\circ C/W$), was observed during the electrolysis of potassium carbonate. This effect was not observed when sodium carbonate was electrolyzed. No trivial explanation (in terms of chemical reactions, change in heat transfer properties, etc.) of this effect were found.

29. Niedra, J., Meyers, I., Fralick, G. C., and Baldwin, R., "Replication of the Apparent Excess Heat Effect in a Light Water-Potassium Carbonate-Nickel Electrolytic Cell, NASA Technical Memorandum 107167, February, (1996). pp. 1-20.; Niedra, J., Baldwin, R., Meyers, I., NASA Presentation of Light Water Electrolytic Tests, May 15, 1994.

NASA Lewis tested a cell identical to that of Thermacore [16] with the exception that it was minus the central cathode. A cell identical to the test cell with heater power

only (no electrolysis) was the calibration control and the blank cell with the heater power equal to zero. The test cell was also calibrated "on the fly" by measuring the temperature relative to the blank cell at several values of heater input power of the test cell. "Replication of experiments claiming to demonstrate excess heat production in light water-Ni-K₂CO₃ electrolytic cells was found to produce an apparent excess heat of 11 W maximum, for 60 W electrical power into the cell. Power gains ranged from 1.06 to 1.68." The production of excess energy with a power gain of 1.68 would require 0% Faraday efficiency to account for the observed excess power.